VOLUNTARY/INVOLUNTARY EMOTIONAL PROCESSES AND AGGRESSIVE BEHAVIOR

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VOLUNTARY/INVOLUNTARY EMOTIONAL PROCESSES AND AGGRESSIVE BEHAVIOR

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To the God of Israel and the lover of my soul, Jesus Christ.

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Lord, I pray that your kingdom come, your will be done on earth as it is in heaven through me and these precious people around me.

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SUMMARY

This study estimated the association between aggressive behavior and two different types of emotion regulation, one operating on the conscious level with voluntary effort (i.e., suppression) and the other operating on the unconscious level with involuntary effort, or automatically (i.e., repression). Results from a correlation analysis among self-assessed suppression and repression and other-rated aggressive behavior showed that repression is more significantly linked to aggressive behavior than suppression. Further investigation using physiological and neural assessments was performed to determine the critical properties, including cardiac reactivity and neural substrates, of repression related to aggressive behavior. Based on the findings from multiple approaches in assessment, this study suggests that unconscious emotion change inferred from self-assessed repression (in Study 1) and neural activity (in Study 2) more significantly predicts aggressive behavior than personality. Implications for both aggression and emotion research are discussed along with the measurement equivalence issue.

CHAPTER 1

INTRODUCTION

Literature Review

Types of Aggressive Behavior

Aggression refers to behavior that is directed toward another individual (or object) with the goal of inflicting harm or injury (Anderson & Bushman, 2002). Under the broad definition of aggression, various forms of aggressive behaviors have been identified in literature. Broad conceptualization of aggression includes overt versus covert (Kaukiainen, Salmivalli, Lagerspetz, Lahtinen, & Kostamo, 1997) and direct versus indirect (Buss, 1961). More specific distinctions of aggressive behavior include relational (Crick, 1995), social (Galen & Underwood, 1997), rational-appearing (Björkqvist et al., 1994; Kaukiainen et al., 2001), and passive aggression (Richardson, Ferguson, & Daniel, 2006).

When multiple widely-used aggression questionnaires are combined, a total of five factors emerged (Verona, Sadeh, Case, Reed, & Bhattacharjee, 2008). They are physical, property, verbal, passive, and relational aggression. Physical and property aggression refers to behavior accompanied by physical force that causes harm to others or the property of others such as kicking or stealing, and verbal aggression refers to yelling at or threatening others. Passive aggression entails expressions of anger in indirect ways by disguising aggressive motives as a more noble cause (e.g., procrastination, stubbornness, obstructionism) (Buss, 1961), and relational aggression entails inflicting harm on others using interpersonal relationships (Crick, 1995).

Studies have found that personality factors such as irritability, rumination, emotional susceptibility (Caprara et al., 1996), low agreeableness (Gleason, Jensen-Campbell, & Richardson, 2004), and low self-esteem (Baumeister, Smart, & Boden, 1998) are some of strong predictors of greater aggression. An integrative review of 63 studies involving both children and adults confirmed the idea that trait aggressiveness (i.e., aggressive personality) affects aggressive behavior under both neutral and provocation conditions (Bettencourt, Talley, Benjamin, &Valentine, 2006).

Once aggression is provoked, however, factors that influence aggressive behavior differ according to the review. After aggression provocation, the featured characteristic of highly aggressive people is their poor emotional susceptibility and greater rumination than others (Bettencourt et al., 2006). That is, highly aggressive people not only have innate aggressive-prone tempers but also find it hard to control their emotions. Franzoi (2009) humorously mentioned in his book that aggressive people tend to “stew in their own angry juices following confrontation” (p. 431).

Despite the importance of successful emotion control in preventing individuals from manifesting aggressive impulses, not all individuals, unfortunately, seem to actively engage in emotion regulation. Instead, a frequently-used tactic for controlling negative emotions is an avoidance strategy that refers to the propensity to deal with stressful life events through suppression, denial, and rationalization (Bryant & Cox, 2006; Byrne, Barry, & Nelson, 1963; Gross, Richards, & John, 2006).

Suppression

A type of conscious, deliberate inhibition of emotional experience or expression in which one maintains a favorable self-image through impression management is referred to suppression (Weinberger & Davidson, 1994). Suppression is often achieved by avoiding explicit expressions of negative emotions (Gross & Levenson, 1993).

One of the main interests of both theorists and practitioners is the effect of the frequent use of the inhibitory emotional strategy of suppression (c.f., Kassinove & Sukhodolsky, 1995). Empirical studies report that suppression is detrimental to both mental and physical health. In a series of experiments, emotion suppression groups reported more intensified experiences of disgust (Gross, 1998), sad (Gross & Levenson, 1997), depression (Goldman & Haaga, 1995), impaired emotion-eliciting memory (Richards & Gross, 2000), and low life satisfaction (Gross & John, 2003) than the experimental control group. Furthermore, research also suggests that social interactions were less satisfying for both suppressors and their interaction partners than non-suppressors (Butler, Egloff, Wilhelm, Smith, Erickson, & Gross, 2003).

Concomitant physiological responses of individuals to suppression, however, are inconsistent across the literature. Studies report that instructions on inhibiting facial expressions during aversive emotional events have led to increases in skin conductance levels and finger pulse amplitude, suggesting that the suppression of negative emotion leads to increased arousal (Gross, 1998; Gross & Levenson, 1993, 1997). In contrast, findings from other studies suggest that participants who are asked to inhibit emotional expression are likely to show decreases in emotional arousal commensurate with the degree of their inhibition of expression (Colby, Lanzetta, & Kleck, 1977; for a review, see Gross & Levenson, 1993).

Repression

The unconscious counterpart of suppression, repression, refers to a type of emotional regulatory process operating on the unconscious level in which one maintains a favorable self-image through self-deception, which is operating unconsciously, by avoiding conscious experiences of pain (Myers, 2000; Shedler, Mayman, & Manis, 1993). Repression is a defense mechanism whereby an individual moves some unwanted, usually painful affects such as excessive anxiety or anger that are painful to keep in the conscious mind to the unconscious mind in order to reduce the conscious experience of pain (Freud, 1946, 1957). The ways of reduction under the defense mechanism of repression include not perceiving the threatening external events or denying the presence of an unacceptable internal psychological state (e.g., a death wish or hostile motivation) (Freud, 1946). In this sense, Erdelyi (2006) viewed repression as an emotional form of justification whereby an individual can relieve psychological discomfort caused by the cognitive dissonance problem. Similar to suppression, the frequent use of repression produces a mixed pattern of adaptive and maladaptive outcomes. Studies show that repressors exhibit a low memory recall rate for emotionally distressful events (Davis, 1987; Davis & Schwartz, 1987), and they are more likely to exhibit heightened autonomic reactions (e.g., increased heart rate, skin resistance, high blood pressure) in reference to their baseline, which often causes physical problems (Derakshan & Eysenck, 1997). Studies also show that repressive coping styles can be a risk factor for cardiovascular disorders and asthma later in life (Asendorf & Scherer, 1983; Newton & Contrada, 1992).

While the effects of repression can be negative, studies on repression suggest that they can also be positive in that repression can serve as an adaptive strategy for coping with stressful life events (c.f., Crammer 1998, 2000). Studies find that people who repress emotions tend to experience fewer negative emotions (Cutler, Larson & Bunce, 1996), have a higher rate of psychological well-being (Coifman, Bonnano, Ray, & Gross, 2007), and exhibit efficient memory performance (Boden & Dale, 2001). The inhibitory emotional strategy used by cardiac patients was related to low anxiety and depression while the acceptance of their physical and psychological conditions was associated with a high mortality rate in the care facility (Froese et al., 1974; Hackett, Cassem, & Wishnie, 1968).

Although the inconsistency in the research findings has been noted by several researchers (c.f., Gross, 1999; Lee, Shackman, Jackson, & Davidson, 2009), a framework that provides a viable explanation for the inconsistency in the psychophysiological measures of suppression/repression has never before been suggested. Since the reason for the inconsistency remains unknown, it is difficult to predict the relationship between psychophysiological consequences of suppression/repression and other individual differences such as aggression.

Thus, the aim of the present study was to decode the nature of the relationship between suppression/repression and psychophysiological consequences, which could explain the inconsistency in the literature. A more comprehensive view of emotion might provide an explanation of the discordant experimental results found in both suppression and repression. One of the attempts to resolve the inconsistency issue can be made by considering both voluntary and involuntary emotional processes on behavior. Thus, this study examined whether suppression/repression or a combination of both makes any difference in physiological responses.

Based on the configuration of the relationship between suppression/repression and physiological responses, this study was also designed to investigate the relationship between suppression/repression and aggressive behavior. Due in part to the lack of research, relatively little knowledge pertaining to the influence of suppression on aggressive behavior in particular is available. Considering the five-factor model of aggressive behavior, this study clarified what type of aggressive behavior suppression/repression is associated with.

The Dissociation of Suppression and Repression

An integrative framework pertaining to the both suppression and repression can be discussed in reference to the dual cognitive processes model, which includes explicit and implicit cognitions that affect behaviors independently but congruently (e.g., Greenwald & Banaji, 1995). The dual cognitive processes model is an attempt to examine both the conscious and unconscious operations of psychological concepts. For instance, personality psychologists distinguish motives from traits and suggest that these two concepts are linked at different levels of consciousness: motives are conceptualized as implicit or unconscious terms that include wishes, desires, or goals. Traits are explicit or conscious concepts, which include predispositions, values, and attitudes (Greenwald & Banaji, 1995; McClelland, Koestner, & Weinberger, 1989; Winter et al., 1998). This implies that a conceptually similar construct can operate on different levels of consciousness and be linked to dissimilar behaviors.

The idea that explicit/implicit cognitions predict different aspects of behavior has been well conceptualized in the dissociative model suggested by Bornstein (1998, 2002). The model suggests the existence of a dissociation between the implicit and explicit components of a psychological construct. Following this model, the operation of passive aggression is largely embedded in and predicted by implicit, unconscious processes (e.g., repression), while active aggression is expected to be associated with explicit, conscious processes (e.g., suppression).

Research conducted in various settings supports this idea that a conceptually similar construct can operate on different levels of consciousness and be linked to dissimilar behaviors. Brustein and Maier (2005) found that implicit achievement motivation significantly predicted task performance while self-assessed explicit achievement goals accounted for the task continuation of participants in a mental concentration task.

In a similar vein, Frost, Ko, and James (2005) suggested that personality-related self-beliefs on aggression, which vary across the levels of implicit motives, determine the aggressive behavioral expression of implicit motives. In their study on the analysis of aggressive behavior in a basketball game, players who believe that they are aggressive and who also possess high levels of implicit aggression are likely to express overt aggression, while those who view themselves as nonaggressive but have high implicit aggression tend to engage in aggression in passive ways. This implies that a conceptually similar construct can operate on different levels of consciousness and be linked to dissimilar behaviors.

Referring to the structure of the dissociative model, this paper proposes that suppression and repression predicts dissimilar emotional and behavioral consequences.

- *Hypothesis 1:* The higher propensity to suppressing negative emotions one has, the more likely this person is to engage in physical, property, and verbal aggressive behavior.
- *Hypothesis 2:* The higher propensity to repressing negative emotions one has, the more likely this person is to engage in passive and relational-aggressive behavior.
- *Hypothesis 3*: The interactive effect of suppression and repression influences the manifestation of aggressive impulses.

Present Research

With the aim to clarify the role of suppression and repression in the manifestation of aggression, this study assessed suppression and repression in participants in two studies. Study 1 assessed individual differences in self-reported suppression and repression and investigated how individual differences in emotional processes predict aggressive behavior in a large sample (N=908). Study 2 approaches emotion regulation as an on-going process using a laboratory paradigm and provides further evidence supporting the distinctive features of repression and suppression and their interactive effect on explaining aggressive behavior using functional magnetic resonance imaging (fMRI).

CHAPTER 2

STUDY 1

Study 1 consisted of two sessions. The first session was a pencil and paper-based questionnaire on personality and emotion regulation. Suppression and repression were assessed on self-report methods. The second session consisted of an online questionnaire regarding the aggressive behavior of the participants in the first session. Responders to the questionnaire were a family member and/or a close friend of the participants in Session 1. The interactive effect of suppression and repression on five types of aggressive behavior assessed by significant others were statistically analyzed.

Methods

Participants

A total of 902 college students in an entry-level psychology class at the Georgia Institute of Technology participated voluntarily in a research study for course credit in Session 1. The mean age of the participants in this sample was 19.5 (*SD*=2.38). In the second session, 712 significant others voluntarily completed the online questionnaire for 459 target participants. About 65% of the participants in Session 2 were family members and 35% of them were friends of the participants in Session 1. Age and gender information was not collected in Session 2.

Measurements

Suppression

Self-report suppression was assessed using the suppression subscale of the Emotion Regulation Questionnaire (ERQ, Gross & John, 2003). The suppression scale consists of four brief statements such as “I control my emotions by not expressing them,” rated on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores were calculated, with higher scores indicating greater emotion suppression.

Repression

Based on the classification of repression suggested by Weinberger, Schwartz, and Davidson (1979), individuals exhibiting high self-assessed defensiveness with low self-reported anxiety were defined as repressors. In this study, defensiveness was assessed by the Marlowe-Crowne Social Desirability Scale (SDS; Crowne & Marlowe, 1964), consisting of 33 items that assess the degree to which individuals attempt to present themselves in a favorable light. Participants were asked to decide whether the statement was true (scored as 1) or false (scored as 0) as it applied to them. Anxiety was assessed by the Taylor Manifest Anxiety Scale (TMAS; Taylor, 1953), consisting of 28 items that assess the trait anxiety. Participants were asked to answer true (scored as 1) or false (scored as 0) to the 28 items. In both scales, higher scores reflected a greater degree of social desirability and reported trait anxiety. With these two scales, the repression index was calculated by subtracting standardized anxiety scores from standardized defensiveness scores.

Aggressive Personality

Aggressive personality was assessed using the Buss-Perry aggression questionnaire (BPAQ; Buss & Perry, 1992). Subscales of this assessment include hostility, verbal aggression, physical aggression, and anger. Using the seven-point scale, participants were asked to rate the degree to which each of 29 statements described themselves. Higher scores reflected a more aggressive personality.

Aggressive Behavior

Following a categorization of aggressive behavior by Verona, Sadeh, Case, Reed, and Bhattacharjee (2008), a total of five types of aggressive behaviors—passive, physical, property, verbal, and relational aggression—were assessed using a behavioral index completed by significant others (e.g., family members and/or close friends).. Among the five categories, physical, property, and verbal aggression are considered overt/direct aggression whereas passive and relational aggression is considered covert/indirect aggression. The behavioral inventory was comprised of 40 sentences describing various behaviors (e.g., "He/She ignores them when they need help."). Raters were asked to indicate how well each sentence described the target person.

Procedure

Session 1 was to assess individual characteristics such as aggressive personality, emotion regulation strategies, and demographical information. If participants in the session wanted to participate in the additional out-of-class session of this research, they expressed their interest by leaving the email addresses of their significant others who had known them more than six months. Then, a behavior inventory, expected to have been completed in approximately ten minutes, was given directly to their significant others via email and asked for voluntary completion. In case that both significant others responded, agreement of two raters on one target participant was assessed using the intra-class correlation coefficient (ICC; Shrout & Fleiss, 1979). The results showed a rating of .325 for passive aggression, .441 for physical aggression, .179 for property aggression, .376 for verbal aggression, and .423 for relational aggression.

Results

Relationship Between Emotion Regulation and Aggression

Descriptive statistics of variables are summarized in *Table 1*. The results of correlation analysis showed that the relationship between repression and suppression was not significant, suggesting that they are independent. *Hypotheses* 1, regarding the relationship between aggressive behavior and emotion regulation strategies, was also tested by correlation analysis (*Table* 1). Results of the analysis showed that four types of aggressive behavior were related to repression. The repression index was positively correlated with passive aggression at .170 ($p<.001$), with verbal aggression at .158 ($p<.001$), with relational aggression at .151 ($p<.001$), and with physical aggression at .149 ($p<.001$). It does not significantly correlate with property aggression. Neither was related to suppression. Additional analyses examined the unique contribution of repression in explaining the variance of each type of aggressive behavior in relation to the aggressive personality indicators. A hierarchical regression analysis was conducted by regressing the aggressive behaviors on the aggression personality indicators (i.e., hostility, verbal aggression, physical aggression, and anger) in the first step. Repression was then added as a predictor in the second step. In the first step, an aggressive personality predicted 17.6 % of the variance in other-rated physical aggression ($R^2 = .176$, $F(4, 408) = 21.83$, $p < .001$). The repressive emotion regulation strategy explained an additional 0.8 % of the variance in the aggressive behavior index (R^2 change=0.8, *F-change* $(1, 407) = 4.20$, $p < .05$). The total variance, explained by both the aggressive personality indicators and repression, was 18.5% ($F(5, 407) = 18.44$, $p < .001$). The results are summarized in *Table* 2. Regression did not explain incremental variance of other types of aggressive behavior.

Table 1. Descriptive statistics and correlations among variables

		N	M	SD	Min	Max	Skew	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Emo Regula-tion	1.Suppression	887	3.77	1.28	.00	7.00	-.06	1										
	2.Repression	888	-.01	.27	-.76	1.03	.04	.036	1									
Agg Persona-lity (AQ)	3.Physical	885	2.76	1.28	.00	8.89	.76	.089**	.192**	1								
	4. Verbal	885	3.54	1.22	.00	7.00	.142	.001	.230**	.427**	1							
	5. Anger	885	2.76	1.14	.00	6.86	.645	-.057	.406**	.482**	.534**	1						
	6.Hostility	885	3.18	1.26	.00	7.00	.118	.163**	.555**	.324**	.350**	.488**	1					
Agg behavior	7. Passive	413	3.10	.99	1.00	6.00	.986	-.031	.170**	.251**	.272**	.247**	.212**	1				
	8.Physical	413	1.47	.65	1.00	6.00	2.47	.024	.149**	.398**	.230**	.270**	.129**	.456**	1			
	9.Property	413	1.25	.47	1.00	5.00	2.87	.059	.046	.283**	.193**	.165**	.069	.409**	.710**	1		
	10.Verbal	413	3.11	1.20	1.00	6.00	.329	-.044	.158**	.343**	.330**	.291**	.189**	.829**	.560**	.449**	1	
	11.Relational	413	2.04	.91	1.00	6.00	1.19	-.063	.151**	.224**	.262**	.245**	.194**	.747**	.496**	.528**	.652**	1

Note. *p*<.05*, *p*<.01**, N=the number of participants, M=mean, SD=standard deviation, Min=minimum, Max=maximum, Skew=skewness.

Table 2. Regression analysis on physical aggressive behavior

	Variables	Unstandardized Coefficients	*t*	*p*	R^2
Step 1 (Personality)	Physical A	.194	6.933	.000*	.176
	Verbal A	.018	.662	.508	
	Anger	.068	2.049	.041*	
	Hostility	-.065	-2.157	.032*	
Step 2 (Emotion regulation)	Repression	.254	2.051	.041*	.185

Note. *p*<.05*, Physical A=physical aggression, Verbal A=verbal aggression.

The interactive effect of two types of emotion regulation strategies (i.e., repression, suppression) on aggressive behavior was also tested. The results showed that their interaction does not significantly account for variances in aggressive behavior.

CHAPTER 3

STUDY 2

Study 2 was designed to investigate the ongoing repressive emotional process. In the experimental condition, suppression was manipulated by giving experimental instructions prior to emotion induction periods using unpleasant image presentation. Repression was not directly manipulated; instead, participants who exhibited high levels of self-assessed repression (i.e., repressors) were recruited and compared with non-repressors. An examination of the interaction between suppression and repression in the experimental paradigm focused on the effects of the combination of the variables group membership (i.e., repressors/non-repressors) and explicit instructions on suppression (i.e., suppressed emotions/watching images naturally) to determine aggressive behavioral outcomes. This examination of the degree to which each of them explained aggressive behaviors included three possible combinations: 1) when participants were given the instruction to suppress (suppress only), 2) when repressors were watching unpleasant stimuli naturally (repression only), and 3) when repressors were given the instruction to suppress emotions (repression-suppression). In order to determine specific information about the emotional processes related to aggressive behavior, the emotion processes of both repressors and non-repressors were assessed in multiple ways, including self-reported emotion experience, heart rate during emotion processes, and neural activity. The degree to which participants reacted to and reduced negative emotions was then correlated with the aggressive behavioral index, and its significance was tested.

In this study, neural responses were assessed using fMRI for the following reason. That is, physiological responses assessed by skin conductivity or heart rate records might not be sufficient tools for monitoring the full range of bodily activity including both unconscious and conscious emotions in response to emotional changes. Failing to cover the full range of emotions may account for the inconsistency in the physiological assessment of suppression in the literature. Since brain scanning techniques provide more precise and wider information about mental mechanisms and bodily reactions than skin conductance levels (Cacioppo & Tassinary, 1990), fMRI was expected to illuminate the relationship between aggression and emotion.

Methods

Participants

Participants were drawn from a pool of undergraduates (*N*=902) who completed questionnaires in Study 1. Among the participants who showed interest in take part in the fMRI session, those who scored high in repression (one standard deviation above the mean) or within the normal range (around the mean and below) were contacted to schedule an experiment. Total nine participants with high repression scores were recruited for high repressor group (HR group), and eight in the normal range of repression were recruited for normal repressor group (NR group). All participants had normal or corrected-to-normal vision and were right-handed. The mean age of the total 17 participants was 19.6 (SD= .5) years. Participants identified themselves as Caucasian (*N*=10), Asian (*N*=4), Hispanic (*N*=1), African American (*N*=1), and pacific islander (*N*=1). The genders, age, or ethnicity of the HR and NR groups did not differ, (χ^2 (1, 16)=1.43, ns; t (16)=.565, ns; or χ^2 (4, 16)=2.95, ns, respectively.

Experimental Task Design and Visual Stimuli

The task was designed to isolate brain activation related to suppression of negative emotions. The condition of interest involved instructing participants to reduce their emotions using suppression ("Suppress"). Following the two prior investigations (New et al., 2009; Phan et al., 2005), a contrast condition used in this study was to instruct participants to freely feel their emotions when they watch negative images ("Watch").

Photographs were selected from the International Affective Picture System (IAPS) (Lang et al., 1997). IAPS images are defined by valence (1 to 9, indicating extremely negative to extremely positive, respectively) and arousal (1 to 9, indicating no arousal to extreme arousal, respectively). Since the manipulation of experimental conditions is based on both valence and the arousal of emotion, images that were evaluated to induce negative emotions were selected for negative emotion-eliciting trials (i.e., 2 to 3 on valence and 6 or higher on arousal). As control stimuli, images with medium levels of valence with low arousal (i.e., 4 to 7 on valence and 4 to 6 on arousal) such as pictures of cups or pencils were presented to participants. All in all, 112 images were used as stimuli for negative-emotion eliciting and 80 images were used as stimuli for neutral-emotion eliciting. All of the images were digitized.

Consisting of instructions and valence of emotion-eliciting images, a total of four types of trials—suppress-negative emotions (SN), suppress-neutral emotions/control condition (SC), watch-negative images (WN), and watch-neutral images/control condition (WC)—were included. During the picture presentation period, each participant underwent these four experimental conditions. During the following rest period, a set of four gray-tone pattern images were presented.

Procedure

Participants completed four practice trials, which gave them time to learn and familiarize themselves with the task. The task in the MRI scanner consisted of 12 trials in one block, and there were total four blocks with 48 trials. Each trial lasted 51 seconds (*Figure* 1). The order of the four types of trials was randomized in all of the blocks. At the beginning of each trial, participants were cued to either suppress emotions elicited by the upcoming images or simply watch them. During the 20 seconds of the image presentation, four pictures were presented consecutively for five seconds each (the picture presentation period). This long second stimulation period was chosen to provide the subjects sufficient time to engage in the target emotion they observed in the first stimulation. Immediately following the picture presentation, participants were asked to report the intensity of their current emotions on a four-button response keypad with a 4-point scale (1=neutral; 2=slightly; 3=moderately; and 4=severely) (Time 1). For the following 20 seconds, participants were given time to clear out or regulate emotions by watching gray-tone pattern images (the rest period), during which time they were expected to recover from their emotions. Immediately after the emotion regulation period, participants were asked to report their current emotions one more time (Time 2), which is the end of a trial. Every 12 trials, the experiment was paused for a short break for about 30 seconds. During fMRI scanning, a heartbeat rate detecting device was attached to the index finger of participants. At the completion of all 48 trials, participants were debriefed and thanked.

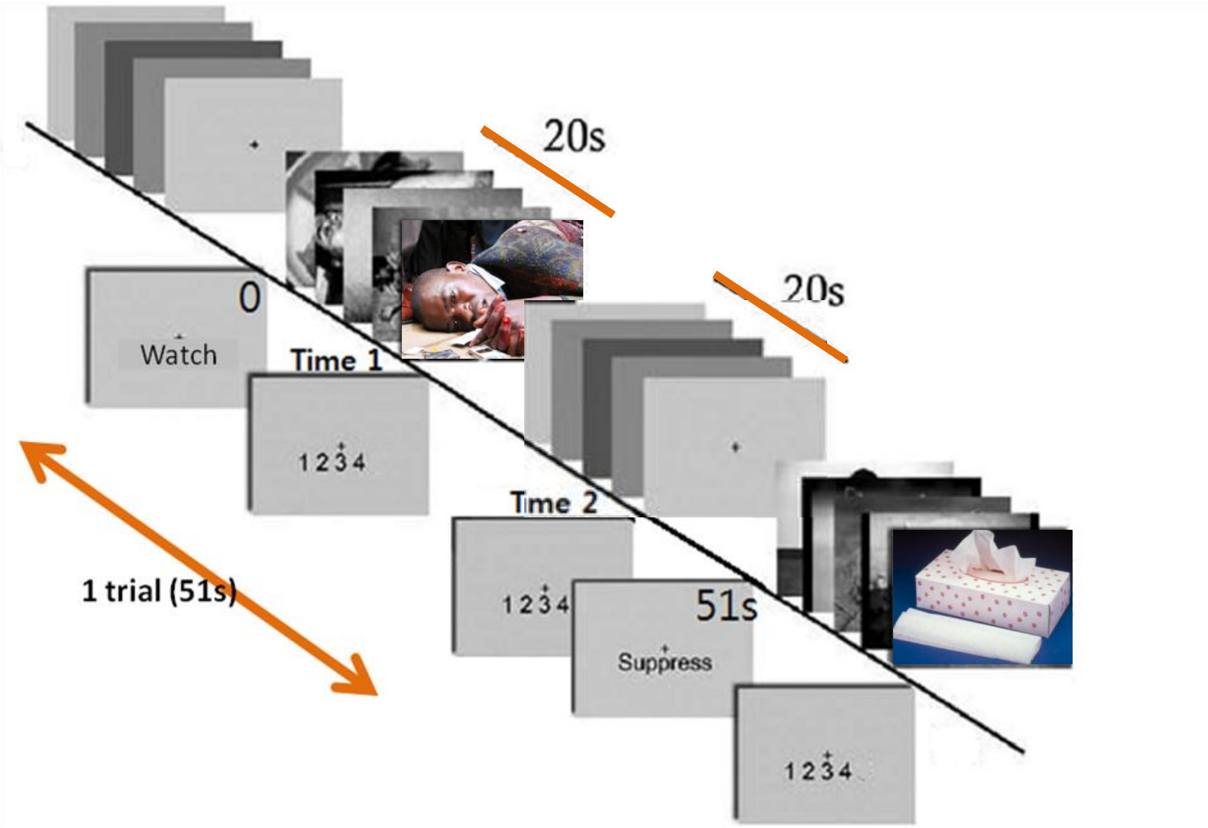


Figure 1. Exemplar segment of the behavioral paradigm for emotion regulation. Preceded by instructions to "Watch" or "Suppress" the evoked emotion, emotional pictures were presented for 20 seconds. Following the picture presentation, gray-tone images were shown for another 20 seconds. Participants reported their emotional states at the end of each presentation.

Image Acquisition

During functional scanning, the blood oxygen level-dependent (BOLD) signal changes of each participant were collected using a Siemens 3T Trio MR scanner with a standard RF coil (T2*-weighted echo planar imaging). 37 slices was collected parallel to the AC-PC plane with TR 2000 and TE 30. Voxel size was 3 × 3 × 3 mm with a slice gap of 0.5 mm. For anatomical reference, a high resolution T1-weighted image (TR=2250 ms, TE=2.52 ms, flip angle=9°, slice thickness= 1 mm) was obtained during the same session. Each acquisition consisted of 218 volumes. The first three volumes of each session did not enter the analysis.

Image Processing and Analysis

Image data were analyzed with SPM8 (http://www.fil.ion.ucl.ac.uk/spm). For preprocessing, voxel time series were interpolated to correct for non-simultaneous slice acquisition within each volume. These interpolated values were then corrected for six-dimensional motion (three linear and three rotational dimensions). Images were slice-time corrected, realigned, normalized to the template created at the Montreal Neurology Institute (MNI). The normalization step resampled the images to a voxel size of $2 \times 2 \times 2$ mm. After the spatial smoothing, the anatomical T1-weighted image of each participant was co-registered to the mean image of the functional images and also normalized to the MNI-space.

The t values of the BOLD signals were used as indices of the size of the statistical effect in each contrast because they provide information about the magnitude of signal changes relative to variability, or noise, in the data (Schaefer et al., 2002; Zarahn, Aguirre, & D'Esposito, 1997). To clarify the nature and direction of the effect, t values extracted from all of the voxels that showed significant group differences in each contrast (i.e., voxels of interest (VOI)) were collected and averaged out according to the group. A correlation of the t values of VOI and the aggressive behavior scales (from Study 1) was estimated using a Pearson two-tailed correlation in SPSS 19.0. The significance level of the correlations was set to $p < 0.05$.

Physiological Recording

Physiological reactivity was recorded using the integrated Siemens Physiological Monitoring Unit. During the functional scans, the cardiac signal was monitored with a pulse oximeter placed on the finger of the participant, which provided a delayed systolic signal as well as the oxygenation saturation level. In the analysis, the participants' heartbeats per minute were summed and used as a physiological response variable.

Results

The emotion processes of participants during the image task were assessed in three ways: self-report, heart beats per minute (HPM), and BOLD signal changes. Each index was analyzed first in the total sample to determine whether the effects of experimental conditions were significant; then, group differences were tested to investigate the differential effect of experimental conditions across groups.

Self-Reported Emotion

The first emotion rating at Time 1, which immediately followed the image presentation, was used to assess the emotional experience of participants upon presentation of the emotional images. The mean emotion rating for the range of responses 1 through 4 was 2.01 (SD=.36).

Total Sample

Results of within-subject repeated measure of ANOVA showed that the level of negative emotions were higher when they watched negative emotion-eliciting stimuli (M=2.77, SD=.51) than neutral stimuli (M=1.24, SD=.24), which suggests successful emotion manipulation in the experiment, $F(1, 16)=21.47$, $p<.05$. In addition, the instruction to suppress exerted a significant increase in unpleasant emotional experience

(M=2.34, SD=.55), compared to the instruction to watch (M=2.04, SD=.30), $t(14)=7.84$, $p<.05$.

<u>Group Comparison</u>

The repressor group and non-repressor group were analyzed separately. The group mean of emotion ratings at Time 1 in each group did not differ significantly. When the combination of the types of stimuli (negative versus neutral) and instructions (suppress versus watch) —SN, WN, SC, and WC conditions—were examined, significant group mean differences were found in the WC condition, $t(14)=8.09$, $p<.05$. In the WC condition, the HR group (M=1.44, SD=.28) reported more intensive negative emotions than the NR group (M=1.13, SD=.11) as they watched neutral stimuli. The mean emotion ratings of all four conditions graphically summarized by the groups are shown in *Figure* 2.

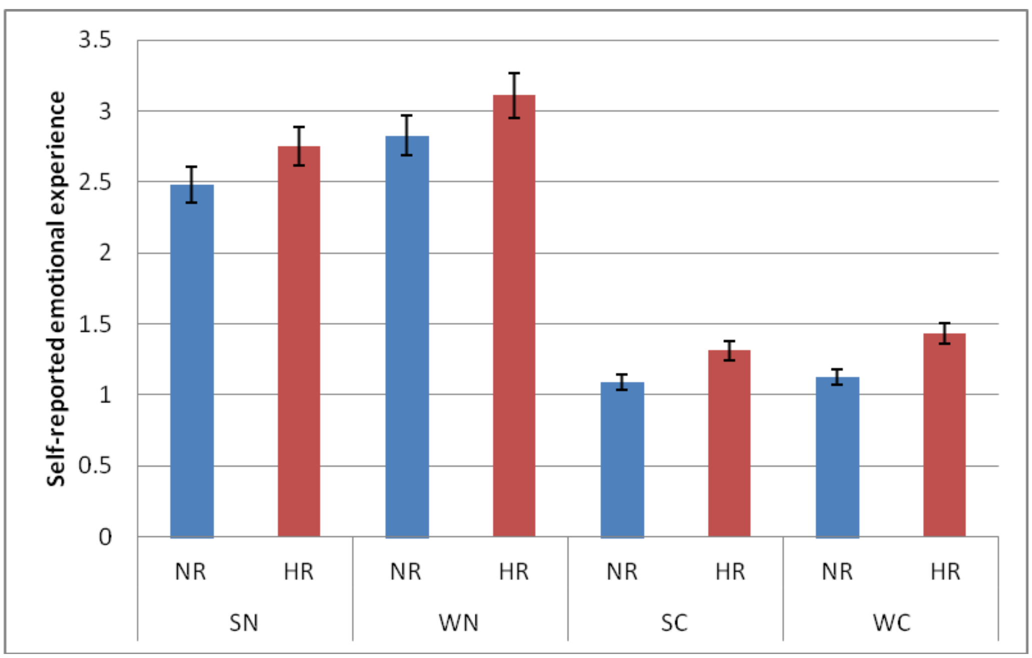


Figure 2. The mean emotion ratings of all four conditions: Group comparison. Error bars represent a 95% confidence interval.

On the second emotion rating at Time 2, which immediately follows the rest period, mean group differences were not found in any of the conditions. That is, participants in both experimental groups reported similar levels of emotional states after the rest period. In addition, two-way ANOVA with repeated measures was conducted to determine the effects of interaction in each group (i.e., a between-subject variable) and a suppression-watching (i.e., a within-subject variable); however, the effect was not statistically significant.

Heart Beat Rate

The heart beat rate, defined as the number of heart beats per minute (HPM) in this study, was assessed during functional scanning. The range of HPM was 50.28 to 99.56 with the mean 70.77 (SD=12.17). HPM during each condition was averaged, yielding four values for four conditions per participant.

Total Sample

A within-subject repeated measure of ANOVA was used to examine whether the main effect of emotional stimuli on the cardiac reactivity of participants during image presentation was significant. Results showed that HPM during the neutral stimuli presentation (M=70.44, SD=13.34) was significantly higher than that during negative image presentation (M=69.81, SD=13.40), $F(1,13)=6.42$, $p<.05$. Similarly, the results of the analysis testing the main effect of the instruction to suppress showed that HPM during the passive viewing condition (M=70.36, SD=13.08) was higher than that during the suppression condition (M=69.90, SD=13.66), $F(1,13)=4.44$, $p=.055$.

Group Comparison

The main effect of the group on BPM was tested using an independent sample t-test. Results of this test showed that HR group (M=63.25, SD=9.67) exhibited significantly lower BPM than the NR group (M=77.99, SD=13.13), $t(14)=6.25$, $p<.05$. As illustrated in *Figure* 3, the mean HPM of the HR group was higher than that of the NR group in all four (SN, WN, SC, and WC) conditions. Two-way ANOVA with repeated measures, in which the group was a between-subjects variable, and the suppress-watch condition was a within-subject variable, showed that the interaction of the group and the instruction significantly explained the HPM of the participants. The HPM of the HR group decelerated as the experimental condition shifted from suppression (M=62.66, SD=9.8) while watching the stimuli condition (M=63.83, SD=9.5) whereas the HPM of the NR group accelerated from suppression (M=78.17, SD=13.17) to watching the stimulus condition (M=77.81, SD=13.10) (*Figure* 4).

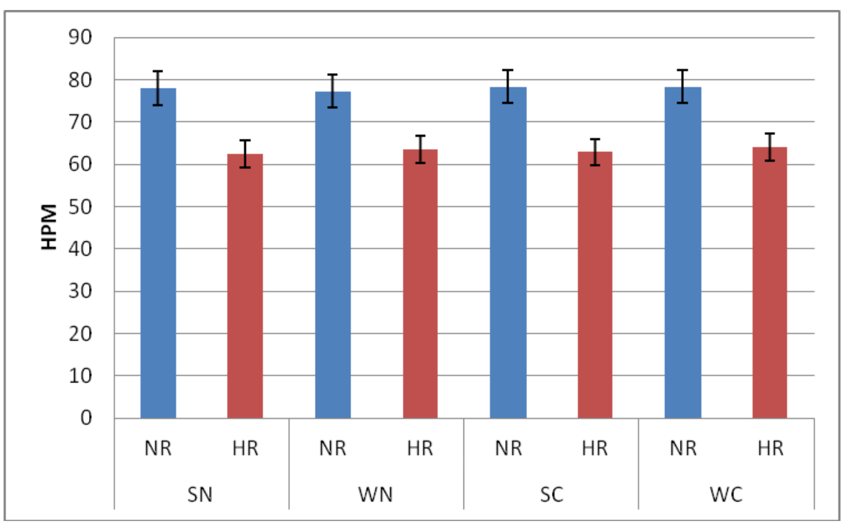


Figure 3. The mean of HPM of each condition by group. Error bars represent a 95% confidence interval.

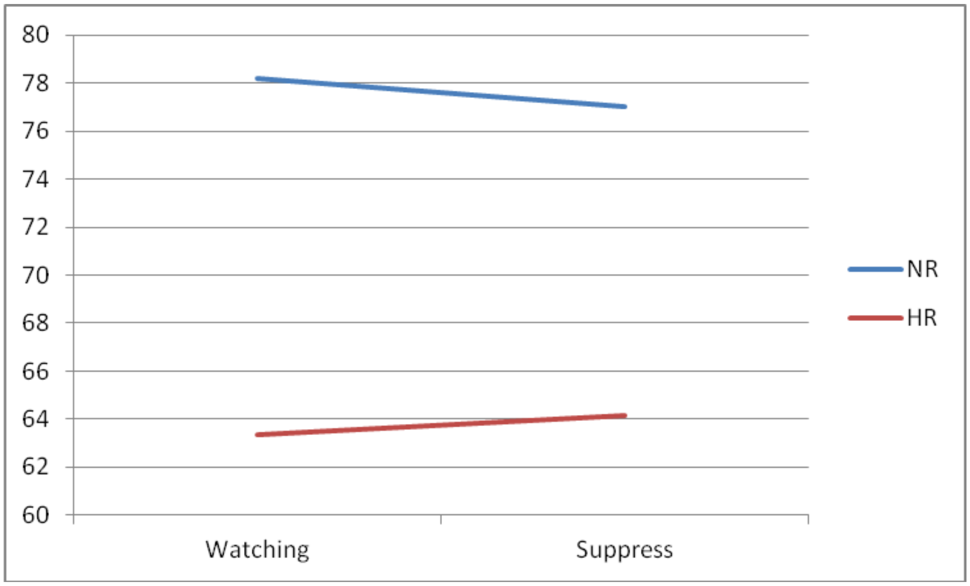


Figure 4. Differential shift of HPM from suppress to watching conditions across groups

Brain Activity

With an aim to determine the effect of emotion suppression/repression on brain activity, this study investigated the brain regions that were more or less activated when the participants were instructed to suppress their negative emotions using contrast analysis. The statistical significance of each contrast was tested at $p < 0.001$ with 10 voxel-extent threshold in the total sample analysis, and it was $p<.01$ with 10 vexel-extent threshold in the group comparison analysis.

<u>Total sample</u>

Negative > Neutral emotions contrast

This contrast is designed to examine the effect of negative emotions on brain activity. Whole brain analyses showed that two regions of the occipital lobe—the left middle occipital gyrus (MOG) and the right fusiform gyrus (FuG)—and three regions of the subcortical brain, including the putamen and the amygdala, become more activated while participants were watching emotional stimuli than when they were watching neutral stimuli. Information about the exact location of these brain regions are listed in *Tables* 3 and 4 using MNI coordinates.

Table 3. Significantly activated brain regions in each contrast: Total sample

Contrasts	Extent	x y z	t	Anatomy	Lobe
Negative > Neutral emotions	773	-45 -73 7	10.32	Middle occipital gyrus L	Occ
	411	42 -46 -20	8.09	Fusiform gyrus R	Occ
	656	12 2 10	7.02	Putmen	Sub
	81	15 -25 -14	5.60	Subcortical cortex	Sub
	69	-21 -1 -14	5.38	Amygdala L	Sub
	10	3 -34 -29	4.78	Cerebellum	CB
SN trials > baseline	6926	-39 -79 -2	25.17	Middle occipital gyrus	Occ
	53	36 -4 -35	5.37	Fusiform gyrus R	Fro
	206	9 20 37	5.15	Anterior cingulated cortex	Fro
	15	42 14 22	4.99	Inferior frontal gyrus R	Fro
	10	0 44 -20	4.77	Rectal gyrus L	Fro
	11	-54 -28 34	4.40	SupraMarginal gyrus L	Par
	11	-21 -37 -41	4.29	Cerebellum L	CB
WN trials > baseline	6317	-42 -67 -11	7.10	Inferior occipital gyrus L	Occ
	20	-24 -37 -41	5.24	Cerebellum L	CB
	23	42 14 22	4.91	Inferior frontal gyrus R	Fro
	11	0 38 -20	4.50	Rectal gyrus L	Fro
	11	-6 14 49	4.39	SupraMarginal gyrus L	Fro
SN > WN	116	42 11 1	6.11	Insula lobe R	Fro
	209	-36 11 10	5.89	Insula lobe L	Fro
	32	9 -31 37	5.59	Middle cingulate cortex R	Par
	16	-54 -31 31	5.09	SupraMargianl gyrus L	Par
	14	21 -10 28	4.95	Parietal lobe R	Par
	26	30 -13 4	4.94	Putamen R	Sub
	118	3 14 43	4.81	Anterior cingulated cortex	Fro
	13	-36 14 -11	4.77	Insula lobe L	Fro
	28	-6 -10 34	4.75	Middle cingulated cortex L	Par
	14	45 -7 -5	4.67	Insula lobe R	Fro
	23	-42 -19 31	4.51	Post-central gyrus L	Par
	25	45 -10 34	4.49	Postcentral gyrus R	Par

Note. x y z=MNI coordination, L=left, R=right, Anatomy=Anatomical labels, CB=Cerebellum, Fro=Frontal, Occ=Occipital, Par=Parietal, Sub=Subcortical, Tem=Temporal. The t statistic is derived from averaging the BOLD response for voxels in the identified cluster for each subject, and then comparing mean BOLD response during each contrast. Effect is significant at $p<.001$. k=10 voxels.

Table 4. Emotion change inferred by BOLD signals: Total sample

Contrasts	Extent	x y z	t	Anatomy	Lobe
SN time 1 > time 2	9355	-42 -67 -11	23.09	Inferior occipital gyrus L	Occ
	382	6 5 55	6.34	Superior medial gyrus	Fro
	11	-45 14 -38	5.54	Medial temporal pole L	Tem
WN time 1 > time 2	5280	-30 -85 -2	24.30	Inferior occipital gyrus L	Occ
	20	42 14 22	5.28	Inferior frontal gyrus R	Fro
	26	0 38 -20	5.21	Rectal gyrus L	Fro
	16	-21 -37 -44	5.10	Cerebellum	CB
	12	-33 -37 -35	4.89	Cerebellum	CB

Note: x y z=MNI coordination, L=left, R=right, Anatomy=Anatomical labels, CB=Cerebellum, Fro=Frontal, Occ=Occipital, Par=Parietal, Sub=Subcortical, Tem=Temporal. The t statistic is derived from averaging the BOLD response for voxels in the identified cluster for each subject, and then comparing mean BOLD response during each contrast. Effect is significant at $p<.001$. k=10 voxels.

WN trials > baseline contrast

This study contrasted the WN trials with the baseline to examine the effect of watching without any voluntary attempt to suppress negative emotions on brain activity. Results showed that the inferior occipital gyurs (IOG), the left IFG, the left cerebellum, the IFG, and the left rectal gyrus, and the SMG during the WN trials. All of these regions overlap with those found in SN trials > baseline contrast.

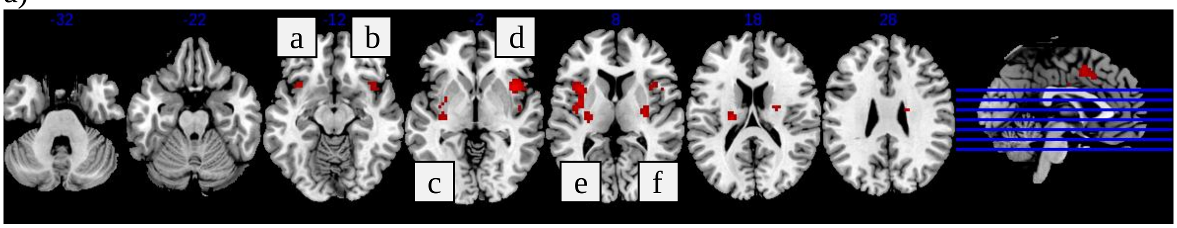
WN Time 1 > Time 2

This contrast analysis was designed to compare BOLD signals *during* and *following* emotional arousal. During the WN trials, the IOG, the IFG, and the rectal gyrus were more activated than they were for the following 20 seconds.

SN trials > baseline contrast

This contrast was designed to identify regions with greater activity during the voluntary suppression of negative emotion. SN versus baseline trials isolated regions engaged by efforts to suppress negative emotions. Whole brain analyses showed that the following brain regions were more active during the SN trials than during the baseline trials: the MOG, the FuG, the right anterior cingulated cortex (ACC), the right inferior frontal gyrus (IFG), the left rectal gyrus, the left supramarginal gyrus (SMG), and the left cerebellum. In addition to the brain regions suggested to engage in negative > neutral contrast (e.g., left MOG and right FuG), three areas in the frontal lobe—the right MCC, the right IFG, and the left rectal gyrus— one in the parietal lobe—the left SMG, and left cerebellum activated compared to baseline.

a)



b)

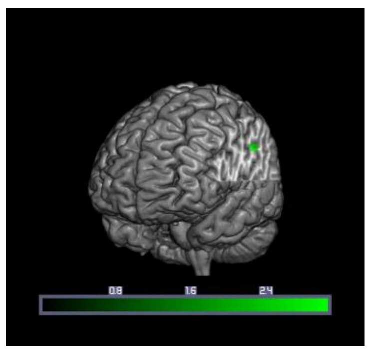


Figure 5. (a) Effects of suppression across all participants (*N*=17). Activation shown in the figure results from the Suppress Negative > Watch Negative contrast, indicating that the following regions were devoted to suppression: a=Insula lobe L, b=Insula lobe R, c=SupraMarginal gyrus (SMG), d= Putamen, e=Middle cingulate cortex L, f= Postcentral gyrus R. (b) Additional view of SMG activation, which is associated with property aggression.

SN > WN contrast

The purpose of this contrast was to determine the brain regions that were relatively more active during the SN trials than they were during the WN trials, extracting the parts relevant to the deliberate effort to suppress from those also relevant to automatic processes at the sight of unpleasant stimuli. Whole brain analysis revealed significant

BOLD signal changes across two conditions in the following brain regions: the insula lobe, the MCC, the SMG, the right putamen, and the postcentral gyrus. *Figure* 5 illustrates the location of the VOIs, and *Figure* 6 shows decreased neural activity during the SN trials compared to that during WN trials.

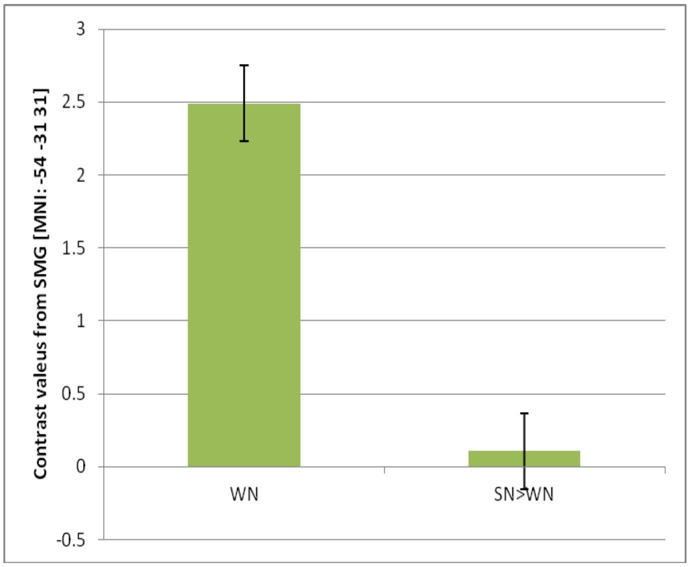


Figure 6. Reduced brain activity in the SMG during suppression. The bar graph shows % signal change of the SMG during the Watch Negative > Baseline Contrast and the Suppress Negative > Watch Negative contrast across all participants. Error bars represent standard errors.

SN Time 1 > Time 2

During the SN trials compared to the following 20 second long rest period, the left IOG, the right superior medial gyrus (SMeG), and the medial temporal pole were significantly more activated.

<u>Group Comparison</u>

Between-group differences in emotional responses were investigated using a contrast analysis separately conducted in each group. In addition, the t values of the voxels of interest (VOIs) that were found significant in the contrast analysis were extracted and compared in groups. The significance of group mean differences in t values was tested using an independent sample t-test. The anatomy label and the *t* value of each VOI were summarized in *Tables* 5 and 6.

Table 5. Significantly activated brain regions in each contrast: Group comparison

Contrasts	Extent	x y z	t HR NR	Anatomy	Lobe
SN trials > baseline	29	-18 -34 16	0.98 0.43	Thalamus L	Sub
	20	33 -46 -2	0.98 0.39	Fugiform gyrus	Tem
	19	-24 -73 -2	1.06 0.42	Lingual gyrus L	Occ
WN trials > baseline	62	-30 -58 10	1.05 0.37	Middle occipital gyrus, L	Par
	11	3 38 34	1.06 0.34	Anterior cingulated cortex	Fro
SN > WN	67	-15 -10 46	1.72 .26	Frontal cortex	Fro
	59	-31 -19 19	1.45 .20	Insula lobe L	Fro
	53	15 -19 1	1.40 0.31	Thalamus R	Sub
	45	6 -52 -35	1.36 0.42	Cerebellum R	CB
	16	-27 -10 -5	1.29 0.44	Putamen L	Sub
	19	42 -13 19	1.07 0.28	Rolandic operculum R	Par
	12	-3 38 -17	1.10 0.40	Rectal gyrus L	Fro
	10	12 -70 -26	1.10 0.54	Cerebellum R	CB

Note. x y z=MNI coordination, L=left, R=right, Anatomy=Anatomical labels, CB=Cerebellum, Fro=Frontal, Occ=Occipital, Par=Parietal, Sub=Subcortical, Tem=Temporal. The t statistic is derived from averaging the BOLD response for voxels in the identified cluster for each subject, and then comparing mean BOLD response during each contrast. Effect is significant at $p<.01$. k=10 voxels.

Table 6. Emotion change inferred by BOLD signals: Group comparison

Contrasts	Extent	x y z	t HR NR	Anatomy	Lobe
SN time 1 > time 2	30	-9 -19 -20	1.06 -0.38	Cerebellum	CB
	30	-24 -76 -2	1.81 0.20	Fugiform gyrus, L	Occ
	10	-15 -19 49	1.43 0.07	SupraMarginal gyrus	Fro
	21	21 -73 1	1.94 0.39	Lingual gyrus R	Occ
	10	-9 50 19	1.93 0.33	Superior medial gyrus L	Fro
WN time 1 > time 2	62	-51 -49 4		Middle temporal gyrus L	Tem
	77	6 41 31	1.16 -0.65	Anterior cingulate cortex R	Fro
	10	27 44 -8	0.98 -0.64	Prefrontal cortex	Fro
	28	33 -43 -5	1.23 -0.52	Parahippocampal gyrus R	Sub

Note: x y z=MNI coordination, L=left, R=right, Anatomy=Anatomical labels, CB=Cerebellum, Fro=Frontal, Occ=Occipital, Par=Parietal, Sub=Subcortical, Tem=Temporal. The t statistic is derived from averaging the BOLD response for voxels in the identified cluster for each subject, and then comparing mean BOLD response during each contrast. Effect is significant at $p<.01$. k=10 voxels.

Negative > Neutral images contrast

Results of the analysis exhibited no group differences in brain activity during the negative versus neutral emotions contrast, which suggests that these groups did not differ in their perception of negative emotions.

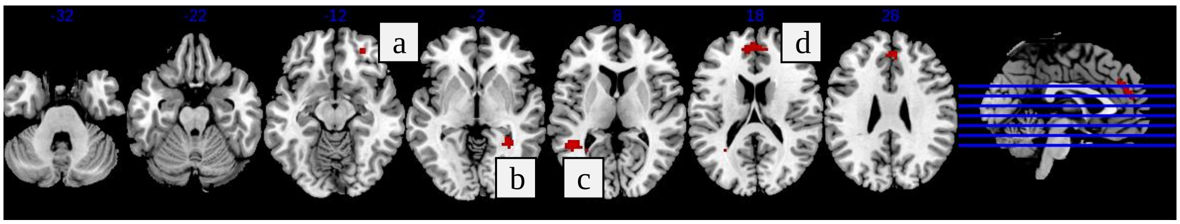
WN trials > baseline contrast

The HR group exhibited greater activation in the parietal lobe and the ACC than the NR group during WN trails.

WN Time 1 > Time 2

Results of the contrastive analysis of the WN trials and the rest period suggest significant group differences in the left middle temporal gyrus, the right ACC, the right parahippocampal gyrus, and a PFC region (*Figure* 7). HR participants had higher *t*-value changes in these regions across time than NR participants during the WN trials. (See *Figure* 8 for a comparison of the mean t value by group.)

a)



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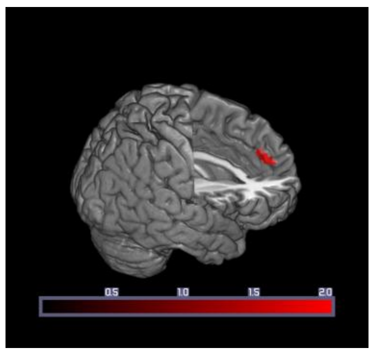

Figure 7. (a) Between-group effects of suppression on the neural response. Activation shown in the figure results from comparing the HR (*n*=9) and NR (*n*=8) groups on the Suppress Time 1>Time 2 contrast, indicating that the following regions were more active in repressors during suppression: a= Middle cingulate cortex R, b=Parahippocampal gyrus R, c=Middle temporal gyrus L, d= Prefrontal cortex (PFC). (b) Additional view of medial PFC activation, which predicts physical aggression

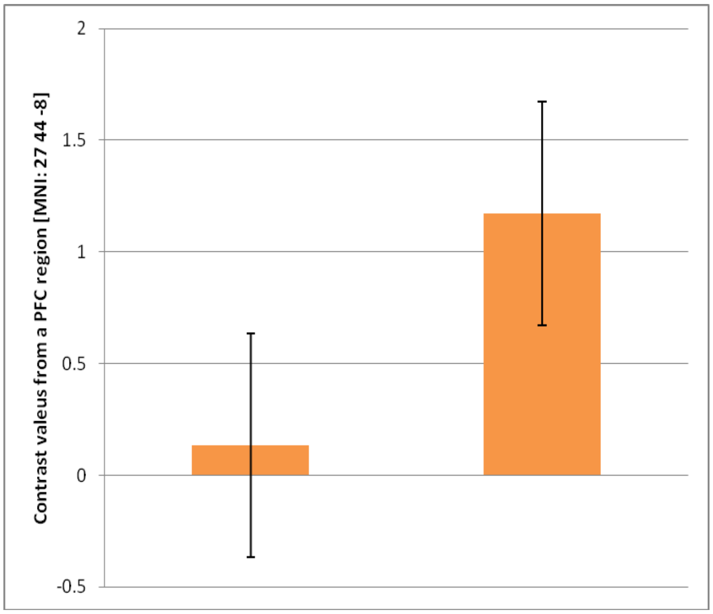

Figure 8. Greater PFC activity across time among repressors found in the Watch Negative Time 1 > Time 2 contrast. Error bars represent standard errors.

SN trials > baseline contrast

The HR group exhibited greater activation in the lingual gyrus, one region in the subcortial area, and one region in the temporal lobe than the NR group during the SN trials.

SN trials > WN trial contrast

Compared to NR group, the HR group exhibited great contrast in the following areas: the left insula lobe, the right thalamus, the right cerebellum, the left putamen, the right rolandic operculum, and the left rectal gyrus.

SN Time 1 > Time 2

A contrastive analysis of the picture presentation period and the rest period was conducted by groups to test group differences. Results showed that significant group differences were in the activity in the right lingual gyrus, the SMeG, and the three regions in the occipital lobes. That is, the HR group recruited significantly more of these regions during SN trials than it did during the subsequent rest time, while the NR group did not show great differences in the level of activation during and following the SN trials.

Relationship Between the Variables and the Aggressive Behavior Scores

The primary interest of this study is the relationship between emotion variables and aggressive behavior. Emotion reactivity and emotion change, assessed via self-reports, HPM, and brain activity in Study 2, were tested to determine whether they had a significant correlation with aggressive behavior assessed in Study 1.

The results of the correlation analysis showed that self-reported emotional experiences did not significantly correlate with aggressive behavior. However, HPM was negatively correlated with a few categories of the aggressive behavior inventory (*Table* 7). Lower mean BPM in all four conditions was associated with higher property aggression (WN condition r= -.551, WC condition r=-.570, SC condition r= -.608, SN condition=r-.528; p<.05), and lower HPM in the SC condition were related to higher physical aggression (r=-.580, p<.05).

Table 7. The relationship between HPM and aggressive behavior

	Passive	Physical	Property	Verbal	Relational
SN condition	-.006	-.489	-.528*	-.170	-.348
SC condition	-.101	-.580*	-.608*	-.238	-.379
WN condition	.016	-.507	-.551*	-.137	-.301
WC condition	-.028	-.514	-.570*	-.181	-.330

Note. p<.05*, SN=Suppress Negative, SC=Suppress Neutral, WN=Watch Negative, WC=Watch Neutral.

Using a regression analysis, this study further compared the predictability of HPM and personality in explaining the behavior of property aggression. In order to avoid the

Type I error, five types of aggressive personality were aggregated to a single value of personality. Results of a hierarchical regression analysis showed that HPM did not explain the additional variance of aggressive behavior over the personality variable.

Results from the correlation analysis showed that the BOLD signals representing activity at the SMG during suppression (i.e., SN>WN contrast) negatively correlated with property aggression at r=-.503 (p<.05). In addition, a region in the frontal lobe (MNI: 27, 44, -8) positively correlated with physical aggression at r=.537 (p<.05).

The t value of the SMG explained the significant incremental variance of property aggression over aggressive personality. In the analysis including physical aggression, aggressive personality predicted 2.3% of the variance in physical aggression in the first step (R^2 = 0.023, F(1, 14) = .33, *non significant*), and the t value of the SMG explained an additional 28.3% of the variance over and above personality in the second step (R^2change =.283, F_{change} (1, 13)=5.31, p<.05). The total variance, explained by all three variables, was 30.7% (F (2, 15)=2.88, p=.09; *Figure* 9).

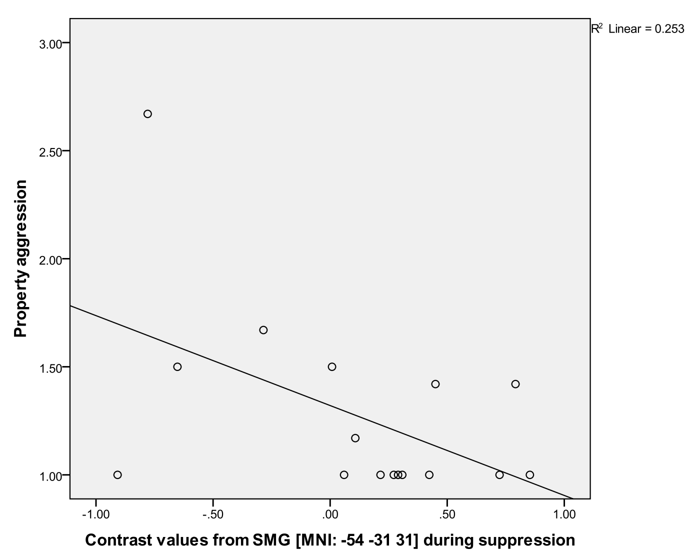

Figure 9. The relationship between property aggression and BOLD activity in the SMG region during the suppress condition.

Results from a hierarchical regression analysis also showed that the t value of the brain region (MNI: 27, 44, -8) during the watching condition explained the significant incremental variance in physical aggressive behavior above the physical aggression-prone personality and self-assessed repression (R^2change =.284, F (1, 13)=2.643, p<.05). However, the significant correlation was not found in the same brain region during the suppression condition (*Figure* 10). The total amount of variance of aggressive behavior accounted for by the two variables was 28.9%. The results not only suggest a neural basis for emotion regulation but also show the superiority of BOLD activity information in predicting aggressive behavior.

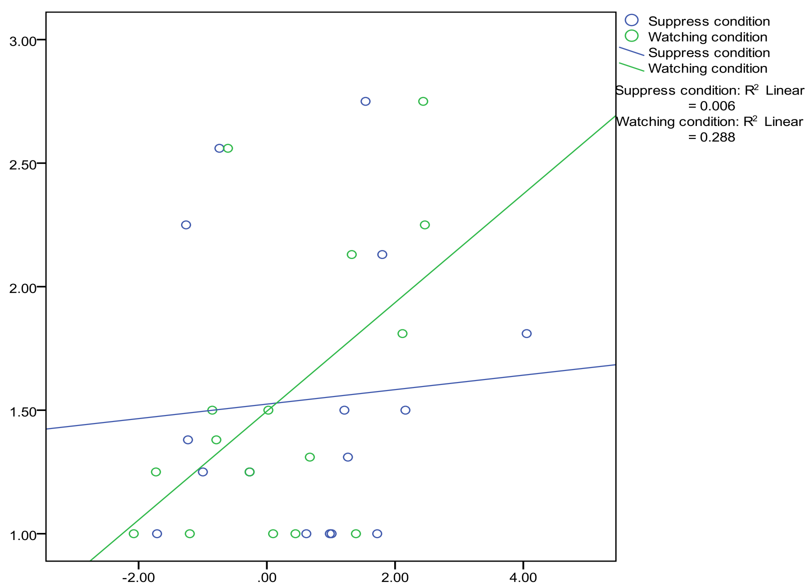

Figure 10. The relationship between physical aggression and BOLD activity in a PFC region during the suppress and watching conditions.

Measurement Equivalence

Strengths of the relationships among the three assessments of emotion regulation (i.e., self-report, HPM, and the BOLD signal) were compared in a correlation analysis. Results showed that self-reported emotion experience and the HPM in the WN and SO conditions negatively correlated (r=-.535, p<.05 and r=-.566, p<.05, respectively).

However, the t values did not significantly correlate with any other assessments. All of the correlation coefficients are summarized in *Table* 8.

Table 8. Correlation among emotion assessments

		1	2	3	4	5	6	7	8	9	10
Self-report	1. SN condition	1.00									
	2. WN condition	.604*	1.00								
	3. SC condition	.579*	.498*	1.00							
	4. WC condition	0.33	0.38	.749**	1.00						
HPM	5. SN condition	-0.35	-.530*	-.601*	-0.46	1					
	6. WN condition	-0.31	-.535*	-.570*	-0.46	.997**	1				
	7. SC condition	-0.32	-.552*	-.556*	-0.44	.996**	.994**	1.00			
	8. WC condition	-0.35	-.553*	-.590*	-0.45	1.00	.993**	.996**	1.00		
BOLD signal	9. SMG (MNI:-54 -31 31)	0.05	-0.20	0.02	0.18	0.12	0.12	0.11	.998**	1	
	10. A PFC region (MNI: 27 44 -8)	0.01	-0.08	0.29	0.16	0.00	0.00	-0.03	0.00	.581*	1.00

Note. *p*<.05*, *p*<.01**

CHAPTER 4

DISCUSSION

Avoidance emotional processes can occur on a conscious or unconscious level (Larsen, 2000). This study investigated the behavioral consequences of both levels of emotional processes using a survey and an experiment. Findings from the two studies showed that repression, which is initiated without awareness, better predicts the aggressive behavior of individuals than suppression, which is performed with voluntary effort. In particular, Study 1 found that individuals who are likely to repress negative emotions tend to engage in passive, physical, verbal, and property aggressive behavior. Study 2 found that emotion change, which was defined by the reduction rate of negative emotions within a certain period of time and inferred from neural activity, predicts property and physical aggression. Consistent with previous research, these findings propose that unregulated negative emotions can be a risk factor for violence and aggression (c.f., Davidson, Putnam, & Larson, 2000). Furthermore, the incremental variance of repression over personality in explaining aggressive behavior underscores repression as a critical predictor to aggressive behavior. The following sections discuss implications for emotion research in relation to the emotional and behavioral outcomes of both suppression and repression and present the measurement issues and limitations of this study.

Revisiting Suppression

The results of non-repressors' efforts at suppressing unpleasant emotions provide information about the main effect of suppression on emotional, physiological, and neurological responses. First, findings of this study showed that suppression was associated with an increase in the heart beat rate during the negative picture presentation. This finding is consistent with previous reports of physiological changes accompanying negative emotions (c.f., Asendorf & Scherer, 1983; Newton & Contrada, 1992).

Findings from the brain-imaging analysis confirmed the previously suggested model of neural correlates of emotion suppression including the prefrontal cortex (for a review, see Davidson, Jackson, & Kalin, 2000), the amygdala (Beauregard et al., 2001; Lane, Fink, Chau, & Dolan, 1997; Zald & Pardo, 1997; Irwin et al., 1996; Schneider et al., 1997), the hippocampus, the hypothalamus (Nomi, et al., 2008), the anterior cingulate cortex (Beauregard et al., 2001; Bush, Luu, & Posner, 2000; Davidson et al., 2000), the ventral striatum, the OFC, the right dorsolateral prefrontal cortex (Davidson et al., 2000; Levesque et al., 2003; Ochsner et al., 2004), the insular cortex (Phan et al., 2005), the lingural gyrus, and the cerebellum (Wolf, Rapoport, & Schweizer, 2009). Consistent with the previous studies, this study found that the insula lobe, the thalamus, and the prefrontal cortex are involved in suppression compared to passive viewing (c.f., Phan et al., 2005) (i.e., the SN > baseline contrast).

The conscious attempt of participants to suppress negative emotions also resulted in the concurrent high activity in the lingual gyrus and the cerebellum, which are involved in regulating fear responses (c.f., Wolf, Rapoport, & Schweizer, 2009). In addition to these areas, this study suggests the SMG, the putamen, the rolandic operculum, the rectal gyrus, and the left superior medial gyrus as neural correlates of suppression, which requires further investigation (i.e., the SN time 1> time 2 contrast).

Suppression and Aggressive Behavior

One of the main foci of this study is the role of inhibitory emotional processes in explaining aggressive behavior. The results of Study 1 showed that self-assessed suppression did not correlate with any type of aggressive behavior. This study suggests the superiority of repression to suppression in accounting for both passive and active aggressive behavior. Although this study hypothesized that suppression might relate to physical, property, and verbal aggression based on the dissociation model, results showed that only repression is associated with both overt and passive-aggressive behavior, demonstrating the dominant role of involuntary/automatic emotional processes in explaining aggressive behavior. The finding implies that to understand human behavior, we should now focus more on unconscious emotions. Emotions, which are not consciously experienced, can substantially affect behavior overtly or on a "concrete" level.

In Study 2, the suppression was experimentally manipulated by instructing participants to suppress their emotions during a picture presentation during MRI scanning; then the degree to which an individual was engaged in suppression was estimated based on assessments of the changes in emotional experience, heart rate, and BOLD signal changes. Results showed that individual differences in the SMG during suppression correlated with property aggression. Thus, Hypothesis 1 was partially supported.

Unveiling Repression

This study investigated the discrete psychological properties of repression. A summary of the featured aspects of repression in terms of emotion reactivity and emotion change specified the psychological stage in which avoidance emotional processes occur. One of the characteristics of the repressor group was differential levels of self-reported emotional reactions to neutral stimuli. Upon the presentation of neutral stimuli, repressors reported more intensive negative emotions than non-repressors. This finding provides evidence that repressors engage in selective processing and suggests that they are vulnerable to experiencing negative emotion (c.f., Dalgleis, Matthews, & Wood, 1999).

Another noticeable aspect of repressive emotional process is a significantly low level of sympathetic activation of the cardiovascular system during an emotional process. This finding, consistent with the biosocial basis of violence, suggests a strong correlation between a low resting heart rate and anti-social behavior (Gottman et al., 1995; Raine, 2002; Schneider, Nicolotti, & Delamater, 2002).

Repressors also exhibited brain activity patterns that differed from those of non-repressors while they were watching negative emotion-eliciting images (i.e., the WN > baseline contrast) without a particular instruction to suppress. Inasmuch as repressors made no explicit effort to regulate emotion in this experimental condition, they were, by definition, likely to engage in involuntary emotion regulation. Based on the fMRI analysis, this study suggests the involvement of the parietal lobe (MNI: -30 -58 10) and in the ACC in repressing negative emotions, supporting previous research that also suggests the involvement of the ACC in the automatic control of negative emotions (Campbell-Sills, 2011; Nomi et al., 2008). Based on neuropsychological research suggesting that electrical stimulation of the ACC in animals elicits aggressive vocalizations (Siegel & Chabora, 1971), and lesions of the ACC in humans are associated with decreased aggressivity (Lewin, 1961; Lilly et al., 1983), this study suggests that the ACC is a neural link between repressors and aggression.

In addition, this study found that the left middle temporal gyrus, the right ACC, and the right parahippocampal gyrus are involved in the changes of repressors following unpleasant emotional experiences (i.e., the WN Time 1 > Time 2 contrast). In particular, researchers revealed that the parahippocampal place area (PPA) plays a crucial role in identifying social context. The increased level of PPA among repressors found in this study confirms the high social desirability of repressors.

In sum, repressors tend to feel negatively toward emotionally-neutral stimuli, and their cardiac reactivity functions maladaptively during emotional arousal. The brain regions activated upon emotional evocation of repressors also differed from those of non-repressors.

Repression and Aggression

This study found that the featured characteristics of repressors are associated with aggressive behavior. The results of study 1 suggest that self-assessed repression was significantly associated with both passive and overt aggressive behavior while suppression was not. In addition, self-assessed repression explains the additional variance in physical aggression above personality. The results of Study 2 show that repressors react emotionally during emotion-eliciting picture presentation without any deliberate effort to suppress (i.e., WN condition). Results of the brain-image analysis showed that emotion reactivity during WN explained the additional variance in aggressive behavior. Thus, Hypothesis 2 was supported.

Interaction Between Suppression and Repression

When the variables of group membership (i.e., repressors versus non-repressors) and voluntary efforts (e.g., suppression versus watching) were combined, they were found to jointly influence emotional and behavioral outcomes. Findings of this study pertaining to deliberate efforts by repressors to suppress demonstrated how an interaction between the two variables resulted in significantly different physiological responses by repressors and non-repressors during emotion arousal and how the seemingly inconsistent findings pertaining to the effect of suppression on physiological responses might be integrated. Research findings showing that suppression is related to reduced physiological responses might be the effect of suppression among repressors whereas findings showing that suppression is related to increased physiological responses might be the effect of suppression among non-repressors (c.f., Lang et al., 1993; Bradley and Lang, 2000).

This study suggests that unconscious processes must be taken into account if the inconsistency among studies with regard to conscious suppression is to be resolved. An explanation for the discordant results in previous experimental studies may be failure to account for ongoing unconscious emotion regulation and the possible interaction between suppression and repression. The present study found that HPM decreased when all participants attempted to suppress emotions, but when the participants were divided into groups based on their levels of repression, the study found that this pattern applied only to non-repressor group. Interestingly, over time, the repressor group exhibited increased HPM following suppression. That is, depending on the level of repression, the effect of the same amount/level of attempt to suppress unacceptable emotions on HPM differed.

The interaction between suppression and repression on HPM suggest that a channeling model may be operating. In general, channeling models propose that explicit (conscious) awareness of self-perception determines the way implicit (unconscious) components are expressed (Winter, John, Stewart, Klohnen, & Duncan, 1998). Consistent with the logic, the results of this study suggest that a conscious effort to internalize emotions (suppression) affects the influence of the unconscious internalization of emotions (repression). Without any explicit effort to suppress, HPM, in which repression can find a way to manifest itself, can greatly vary. As *Figure* 3 illustrates, when the instruction to suppress was not given to participants, the gap of HPM between repressors and non-repressors was significantly large, suggesting the influence of repression on HPM.

This integrative perspective can provide not only an important window into understanding discrepancies among existing findings, but also practical implications for emotion regulation. For example, advice to suppress emotions such as "Hold on to your anger" or "Bear with it" would not help everyone experiencing stressful situations. Based on the findings of this study, only suppressors who have low repression level may benefit from such advice by reducing their physiological arousal.

The Interplay of Repression and Suppression on Aggressive Behavior

In Study 1, the interaction of self-assessed repression and suppression did not significantly account for variances in aggressive behavior. In Study 2, the joint effect of repression and suppression observed in the experimental paradigm predicted aggressive behavior. Results from both hierarchical regression and brain-image analyses in Study 2 showed that during watching condition, neural activity in a PFC area, which is particularly responsive to repressors, predicted physical aggression over personality (see *Figure* 10). However, during the suppression condition, in which explicit efforts constrain the manifestation of unconscious motivation, neural activity in the same area did not predict aggression. Therefore, results from this study suggest that when the level of suppression is low, the influence of repression greatly varies according to the level of repression; however, when the level of suppression is high, the influence of repression on aggressive behavior was restricted. This interactive pattern found in this study supports *Hypothesis* 3.

Implications for Measurement Issues

Because of the significance of repression in relation to aggression, this study further investigated the psychological properties of repression in three ways—self-assessed emotion experience/change, HPM, and BOLD activity—that contributed to the examination of the measurement equivalence of repression assessments. The high, significant level of correlations between self-report and HPM provides evidence of the correspondence between behavioral and physiological systems.

With regard to the validity of the criteria, the physiological and neural assessments showed a higher predictability of aggression. Although self-report emotional experience was not associated with aggressive behavior, BPM significantly correlated with aggressive behavior, suggesting that the higher HPM is, the lower aggression is. In addition, the BOLD activity, although it did not significantly correlate with other variables, significantly predicted property and physical aggression. This finding suggests that neural activity is a valid index of repression as well as a significant predictor of aggression. All in all, this study suggests the effectiveness of non-self-report assessment on emotion research, particularly when assessing the interaction between conscious and unconscious emotions.

Limitations and Suggestions

Although over 900 participants completed Study 1, only 14 were invited to participate in Study 2. The sample size was acceptable in fMRI analysis, in which all statistical tests assume that data points are independent samples of the underlying population, so each trial of image presentation can be regarded as independent (Desmond & Glover, 2002); however, the lower statistical power in the correlation and regression analysis is attributable at least in part to the small sample size. Thus, instead of making a general conclusion, this research shows the possible link between emotion regulation strategies and aggressive behavior as a preliminary study. In future studies, more participants must be recruited so that the link between neural activity and behavior can be confirmed.

Another caveat was the effectiveness of instruction in the experiment. Although participants were trained before performing the emotion suppression task in the scanner room, it is uncertain whether they were unable or they refused to follow instructions. In further studies, a method of rigorously controlling the inner strategies of participant should be developed and participants should be asked about the degree to which they engage in suppression of their subjective emotional experiences.

To further support the findings of this study, future research could assess various types of physiological responses. For example, skin conductance is mainly affected by the sympathetic nervous system whereas the heart rate is affected by both sympathetic and parasympathetic nervous systems. Thus, the assessment of various physiological processes would extend our understanding of involuntary responses that take place during emotion regulation.

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